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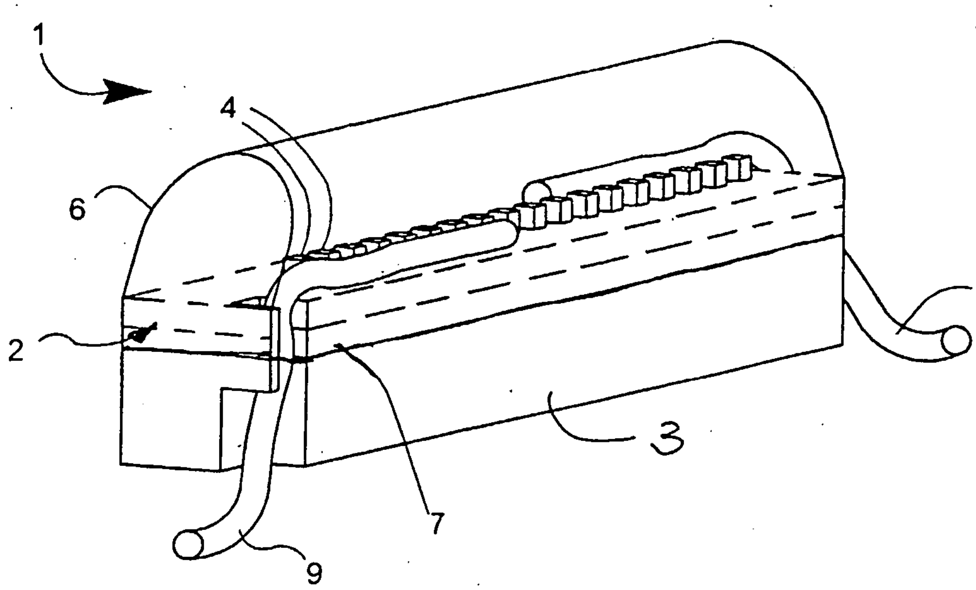
(54) Title: ILLUMINATOR



(57) Abstract: An illuminator (1) comprises a substrate (2) supporting light source dies (4) driven via wire bonds (5). The substrate (2) comprises a silicon strip (20) in direct contact with a brass heat sink (3), thus providing for excellent heat transfer away from the die (4). Pads (10, 11, 12) of Ni, Ti, and Ag sub-layers support the die (4) and the wire bonds (5). These both provide electrical connections for the die (4) and also light reflection upwardly because the Ag sub-layers of the pads (10, 11, 12) are evaporated over a thermally grown oxide layer (21) on the Si (20). The oxide has a very high dielectric strength, thus maintaining excellent electrical insulating properties over a large voltage range.

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ILLUMINATOR

INTRODUCTION

Field of the Invention

The invention relates to illuminators for applications such as machine vision systems.

Prior Art Discussion

Illuminators based on light emitting diodes (LEDs) are widely used for machine vision, sensing, alignment, medical, sorting, ambient lighting and other applications. For many applications such as line sources, backlights and ring lights, attributes of high power density and uniformity at the target are desirable.

Such attributes are not readily available from LEDs. These are grain sized die of semiconductor material which emit light when an electric current is passed through the device. The light emitted from an LED die is highly non-directional, being quasi-isotropic, and is spatially non-uniform in radiant intensity (defined as the radiant flux emitted per space angle, W/sr).

In one prior approach, to address the problems of non-directionality and non-uniformity LED die have been packaged by mounting each die inside a metal reflecting cup, the whole then being surrounded by an encapsulating epoxy or plastics material in the shape of a lens. Degrees of directionality and uniformity of light output are achieved by the operation of the shaped reflector and by the lensing effect. A disadvantage is that the space occupied by a packaged LED is much larger than the space occupied by a LED die so that packing density is greatly reduced in the case of arrays of packaged LEDs. To produce an illuminator, one or two dimensional arrays of packaged LEDs are mounted onto circuit boards in rows

printed circuit board (PCB) technology. This limit on packing density is particularly acute where a multiple wavelength illuminator is required. Such an illuminator requires a multiplicity of metal interconnect tracks for electrical biasing and driving of the different LEDs needed, one type for each wavelength. The pattern size limitations of PCB technology mean that the LEDs have to be more widely spaced apart in multiple wavelength illuminators thus reducing packing density and increasing size and bulk. Another problem is that there appears to be significant internal absorption within the illuminator. A further problem is heat build-up due to the thermal insulating properties of the epoxy.

The invention is therefore directed towards providing an illuminator and method of production to achieve improved power density and uniformity at a target.

Another object is to achieve improved robustness and reliability in an illuminator.

SUMMARY OF THE INVENTION

According to the invention, there is provided an illuminator comprising light sources mounted on a substrate and an integrally moulded lens covering the light sources, characterised in that,

the substrate comprises a layer of semiconductor material and pads of conductive and reflective material overlying the semiconductor material,

said pads are electrically connected to the light sources to provide power, and

the substrate is mounted directly on a heat sink.

In one embodiment, said sub-layers each have a depth in the range of 50 nm to 3 microns.

In another embodiment, said light sources comprise semiconductor die placed and wire bonded on said tracks.

According to another aspect, the invention provides a method of producing an illuminator of the type comprising light sources mounted on a substrate and an integrally moulded lens covering the light sources, the method comprising the steps of:

providing a semiconductor material base,

depositing pads of electrically conductive and optically reflective material on the base to provide a substrate,

placing the light sources and electrical connectors on the pads of the substrate,

adhering the substrate at a lower surface of the base to a heat sink, and

moulding a lens over and around the substrate to hermetically seal the substrate and the light sources.

In one embodiment, the invention comprises the further step of growing an oxide layer on a surface of the base, and depositing the pads on the oxide layer.

In another embodiment, the oxide layer is grown to a depth of at least 2 microns.

In a further embodiment, the base is of silicon material and the oxide is silicon dioxide.

density. The illuminator 1 may be used alone or a number of them may be mounted together in a desired configuration according to the application.

The illuminator 1 comprises a planar substrate 2 mounted on a brass heat sink 3 of rectangular block shape. The substrate 2 supports a line of light emitting semiconductor die 4 and bond wires 5 for activation. A semi-elliptical body 6 of transparent epoxy is moulded over the substrate 2 and it overlaps the sides of the substrate 2 and the top of the heat sink's sides to form an hermetic seal. The overlapping portion is indicated by the numeral 7.

As shown in Fig. 2 the substrate 2 comprises a series of central tri-metal pads 10(a), 10(b), 10(c), and 10(d). There are also a series of lateral wire bond tri-metal pads 11(a), 11(b), and 11(c) on one side and a series 12(a), 12(b), and 12(c) on the other side. The die 4 are mounted in a straight line on the central pads 10 with a packing density of 4 per mm. The die 4 are of the AlGaAs type emitting at 660nm wavelength. The wire bonds 5 bridge the dies 4 and the lateral pads 11 and 12.

Referring to Fig. 3, production of the substrate 2 is now described. Initially, a silicon (Si) strip 20 of dimensions 50mm long by 5mm wide is provided. The Si acts as an excellent thermal conductor.

SiO_2 oxide 21 is then grown on both faces of the Si strip 20. The depth of the oxide 21 is 2 microns, and it is grown by thermal oxidation The top oxide layer is used for supporting the pads and it is an excellent electrical insulator for insulation of the pads 10, 11, and 12 and the wire bonds. Also, the dielectric strength is in the range of 5 to 10×10^6 V/cm. Thus, high voltages (in the range of 10V to 220V) may be applied to the illuminator without oxide breakdown.

In the next step a tri-metal layer 25 is grown over the top oxide layer 21. The metal sub-layers are grown by evaporation as follows:-

performed very quickly after deposition of the tri-metal layer to avoid oxidation on the Ag surface and thus ensure that it is highly reflective. The heat sink/substrate assembly is placed upside-down in the mould, and epoxy is injected underneath. The mould is shaped to ensure that the epoxy fills completely as it is injected the higher-level end and there is gravity flow. The mould is shaped to ensure that the epoxy 6 not only covers the substrate 2, but also extends downwardly over the top of the heat sink side edges to hermetically seal the whole unit. The mould is then baked at 80°C for one hour to cure the epoxy.

In the above embodiment the silicon strip 20 is 5mm wide, the pads 11 and 12 each being 1.9mm wide. The length is 50mm. However, the dimensions may be different to suit the required number of dies and their relative positions. Also, the dies may be of a variety of types in the one illuminator to achieve the desired colour illumination. There may, for example, be R, G, and B dies, and a separate lateral pad associated with each set. The technique for applying and patterning the tri-metal layer 25 allows excellent versatility for achieving a desired configuration of drive.

Regarding the epoxy 6, this is of the type marketed as E501™ by Epotecny of Levallois-Perrit, France. However, the epoxy composition and mould shape may be different to suit the particular application. For example, if a broader line of illumination is required the shape may be semi-cylindrical rather than semi-elliptical. There is excellent versatility because the desired light output spread is easily set by choice of mould shape.

The illuminator 1 may be regarded as a building block for a composite illuminator having multiple such illuminators. For example, referring to Fig. 4 a ring illuminator 30 comprises eight illuminators 1 mounted in an inwardly-directed ring configuration on a plastics support 31. Where there is particularly high power and/or die density, the outer support may also be of a heat sink material.

Claims

1. An illuminator comprising light sources (4) mounted on a substrate (2) and an integrally moulded lens (6) covering the light sources, characterised in that,

the substrate (2) comprises a layer (20) of semiconductor material and pads (10, 11, 12) of conductive and reflective material overlying the semiconductor material,

said pads (10, 11, 12) are electrically connected (5) to the light sources (4) to provide power, and

the substrate is mounted directly on a heat sink (3).

2. An illuminator as claimed in claim 1, wherein the moulded lens material extends completely over the substrate (2) and a top portion of the heat sink (3) to hermetically seal the substrate and the light sources (4).

3. An illuminator as claimed in claims 1 or 2, wherein the substrate (2) comprises a layer (21) of electrically-insulating material over the semiconductor material (20) and the pads (10,11,12) overlie said electrically-insulating layer.

4. An illuminator as claimed in claim 3, wherein said electrically-insulating material comprises an oxide of the semiconductor material.

5. An illuminator as claimed in claim 4, wherein the oxide is thermally grown and has a dielectric strength in excess of 5×10^6 V/cm.

6. An illuminator as claimed in claim 5, wherein the oxide comprises SiO_2.

providing a semiconductor material base (20),

depositing pads (10,11,12) of electrically conductive and optically reflective material on the base (20) to provide a substrate (2),

placing the light sources (4) and electrical connectors (5) on the pads of the substrate,

adhering the substrate (2) at a lower surface of the base (20) to a heat sink (3), and

moulding a lens (6) over and around the substrate (2) to hermetically seal the substrate and the light sources (4).

16. A method as claimed in claim 15, comprising the further step of growing an oxide layer (21) on a surface of the base (20), and depositing the pads on the oxide layer (21).

17. A method as claimed in claim 16, wherein the oxide layer is grown to a depth of at least 2 microns.

18. A method as claimed in claims 15 or 16 wherein the base (20) is of silicon material and the oxide is silicon dioxide.

19. A method as claimed in any of claims 15 to 18, wherein the pads are deposited by patterning with use of a photo-resist.

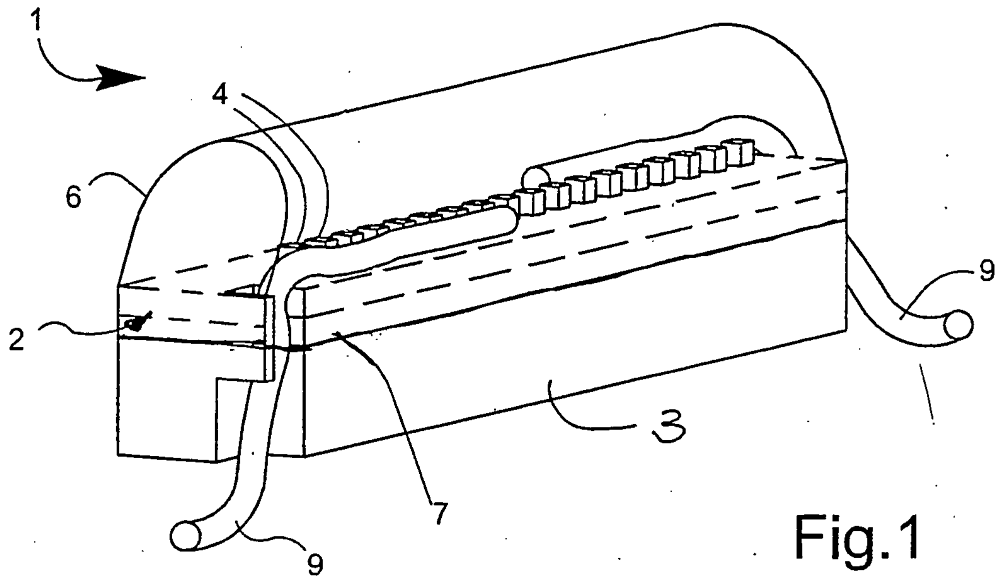

Fig.1

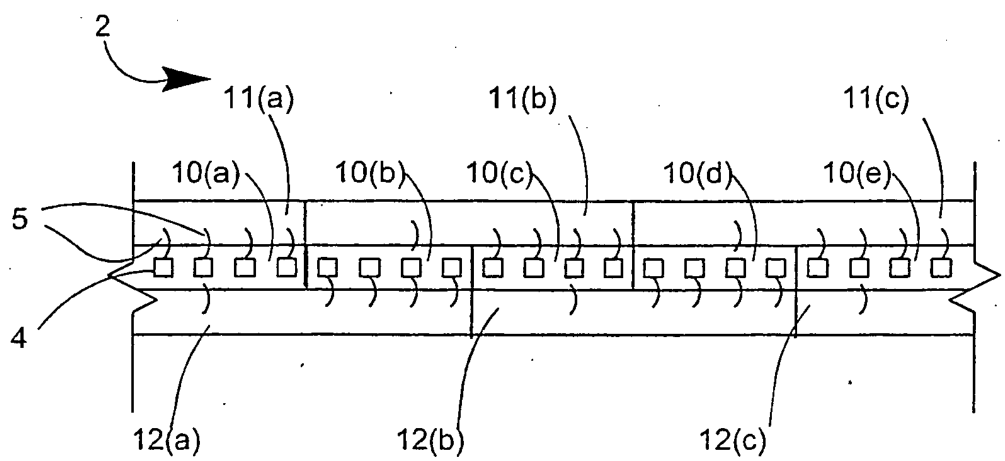

Fig.2

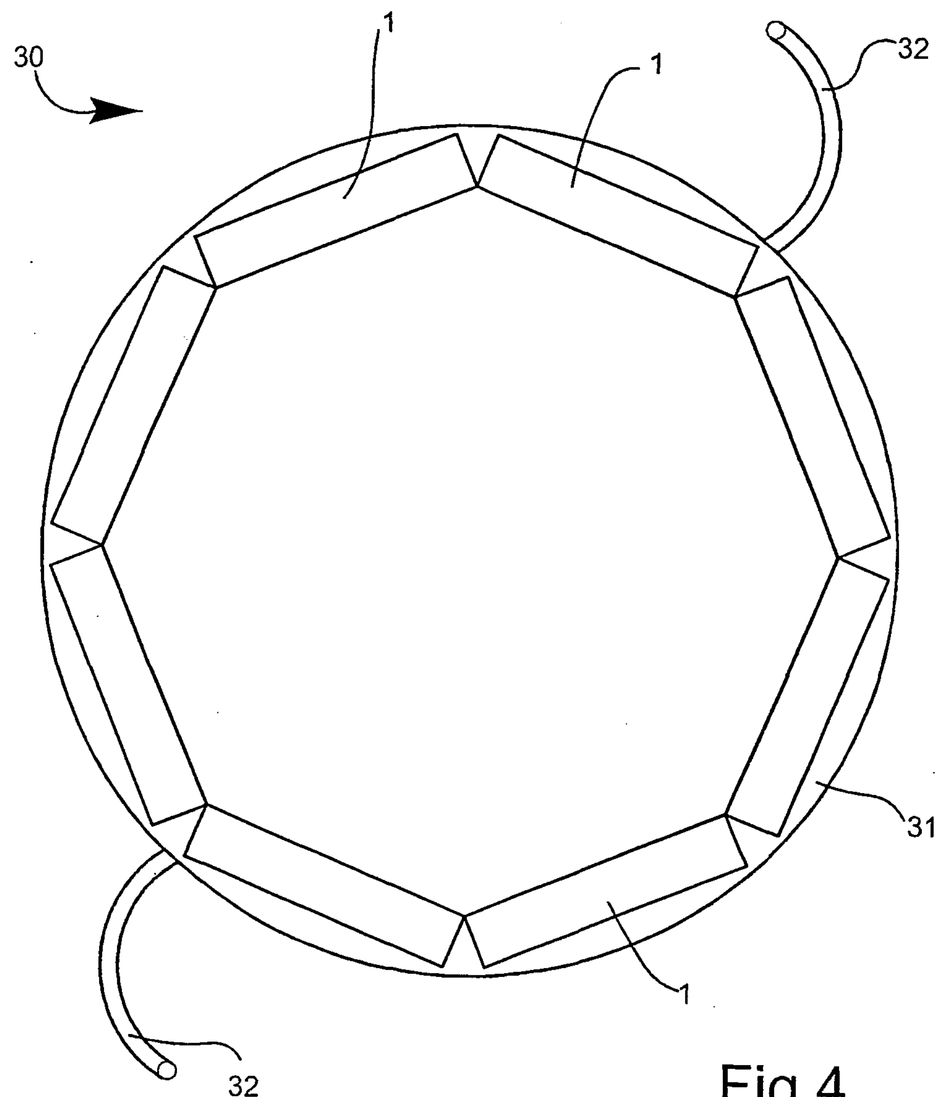

Fig.4

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 276 032 A (PRP OPTOELECTRONICS LTD) 14 September 1994 (1994-09-14) the whole document ---	1,2,14, 19
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 054 (E-583), 18 February 1988 (1988-02-18) & JP 62 200776 A (ALPS ELECTRIC CO), 4 September 1987 (1987-09-04) abstract ---	1,4,8,9, 14-16
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 453 (E-1417), 19 August 1993 (1993-08-19) & JP 05 102522 A (STANLEY ELECTRIC CO), 23 April 1993 (1993-04-23) abstract ---	8-14,19
P,X	WO 02 05357 A (OSRAM OPTO SEMICONDUCTORS) 17 January 2002 (2002-01-17) page 11, line 13-36; claims 1-3,7 -----	1,2,8, 15,20

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-19

   Illuminator comprising a lens, LED light sources, a semiconductor substrate with connection pads, mounted on a heat sink, and a method for its manufacturing

2. Claims: 20-21

   Method for moulding a lens using a sloped mould cavity